Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 45 No. 3
M arch 2024

Plastic Bottle Collector Bin with Dispenser

Dr. Karlo S. Sira [1], Dr. Pablo N. Minerva,Jr[2], Dr. Ernie A. Daitao[3], Arthur E. Villagracia[4]
[1, 2, 3, 4]Iloilo Science and Technology UniversityLa Paz, Iloilo City 5000, Philippines

Abstract
This experimental study aimed to determine the performance of the plastic bottle collector with a dispenser (PBCBD) to collect and disposable bottles using natural forces gravitation force and need no electric power to dispense. The device was subjected to technical panel evaluation. These panellists were experts in their field. Minor revisions were recommended to enhance the device further. Furthermore, the device was tested regarding dispensing time and efficiency. A researcher-made questionnaire was utilised to measure the objectives. The technical evaluators recommended the PBCBD for the university's utilisation of plastic bottle collection and dispensation.

Keywords:Plastic bottles, High-density polyethylene, Dispenser, Garbage collector, Recycling.

1. Introduction

Plastic bottles are formed using various techniques, and the choice of material varies depending on the application. High-density polyethene (HDPE) is the most widely used resin for plastic bottles (Iqsdirectory.com, 2024). It is a common commodity because it is portable and convenient to use.

According to the International Bottled Water Association (IBWA) (2017), water bottle sales have increased almost every decade in the United States for more than a decade. In 2011, greater than $11 billion was spent on U.S. bottled water products. IBWA states that Americans increasingly rely on water bottles for convenience and portability (IBWA, 2022).

Kehinde, Ramonu, Babaremu, and Justin (2020) argued that chemicals used to make some types of bottles are detrimental to the health of humans. Inhalation of chemicals used in manufacturing plastics is a hazard for the factory workers who handle the material. In many developing countries, plastic waste is burned rather than recycled or deposited in landfills. Cosier (2022). Rural residents of developing countries who burn plastic as a disposal method are not protected from the chemical inhalation hazards associated with this practice. Inhalations of the pollutants produced from burning plastics have been shown to result in poor health outcomes.

Halden (2010) further stressed that it is essential to dispose of water stored in PET bottles before expiration because harmful chemicals may leach from the plastic. Rustagi, Pradhan, and Signh (2011) stressed that plastic is a famous industrial material and poses a significant threat to the environment and consumer health through direct and indirect means. Exposure to harmful chemicals during manufacturing, leaching in food items, and chewing plastic toys can lead to adverse health outcomes like cancer, congenital disabilities, and developmental issues. Urgent action is needed to promote plastic substitutes and ensure safe waste disposal.

The Pacific Institute is an American non-profit research institute established in 1987 to conduct independent research and policy analysis on development, environment, and security issues, focusing on global and regional freshwater issues. The institute aims to find solutions to water shortages, contamination, environmental conflicts, climate change, and environmental terrorism, collaborating with stakeholders to advance environmental protection, economic development, and social equity nationally and internationally in California.

The identified problems motivated the researchers to design and develop a device to collect plastic bottles, which would help the government campaign for a plastic-free environment.

2. Literature Review

2.1 Dispensing Technology

Wilson (2023) mentioned that in 1970, governments prioritised environmental issues as their primary concern, leading to the development and production of technology compactors for waste management, which are used for all types of waste management.

Klepacki's 1996 research on a trash handling device focuses on a compactor that holds a container with a plastic garbage bag attached. A pivoting shaft or lever controls the compactor, minimising trash build-ups on the plastic bag and preventing the user from accessing the housing. Safety locks are also installed to avoid accidentally opening the swinging trash door during operation.

In contrast, the present study focuses on waste collection and dispensing, controlled by a shaft or lever inclined at a certain angle using gravity pull. Safety locks are installed for safety purposes. The device only compacts trash in a plastic bag with door locks to keep the bin door closed. In the present study, the dispensing of used plastic bottles is automatically deposited inside the plastic bag, locks are automatically set after dispensing, and the plastic bags are packed.

2.2 Efficiency Technology

Every waste generator, independent of organisational position, is clearly responsible for the device's efficiency. It must be applied from collection, storage, and dispensing to final disposal.

Carson's research study on the "Truck Body and Apparatus for Automated Collection of Recyclable Materials" (1991) outlines a mechanised trash pickup system with three elements: collection, segregation, recycling, and waste dumping. The first element allows separate, open-topped plastic containers for easy removal, transportation, and waste disposal. When a material is to be taken outside for pickup, it is lifted by a handle and carried to an outdoor container with three bins. The contents of the outdoor container are then mechanically picked up by a compartmented truck with mechanised pickup capability. The inside bin is then returned to the indoor container, with some materials requiring more frequent dumping. The second element is a clamping arm assembly with horizontally extending clamp arms attached to a framework and hydraulic linear actuators moving the arms laterally inward or outward.

The study by Carson (1991) focuses on a mechanical, computer-controlled trash pickup system that allows households to sort and transfer trash to a curbside container quickly. The system also includes a trash truck body that selectively dumps separated trash into matching bins in the truck body. The equipment includes a point-of-use trash container with multiple removable, transportable bins for sorted trash, an outside container with matching bins for receiving separated trash, and clamping arms for clamping the outside container and selectively opening its lids. The truck body also includes controllable arms connected to the clamping arms, supported by a carriage that moves along the longitudinal side of the truck body. The arms are controlled to pick up the outside container and sequentially dump the bins into matching truck body bins.

The study focuses on collecting and dispensing plastic bottles of various sizes and shapes, with compartments for easy disposal. Each compartment has a swing door for plastic bags. The device is similar to Torres-Muniz et al.'s (2016) "Modular Garbage Collection Apparatus," which simplifies the recycling bin's sorting process. The device compresses bottles or cans to accommodate more material, allowing easy replacement of compression, classification, and storage units.

The study focuses on collecting and dispensing plastic bottles. The idle device is located in an open area to withstand weather conditions. The collection is not regular but depends on the number of bottles collected. Dispensing is done manually, using natural forces and nature. The device is designed to be a modular arrangement that allows for easy compression, classification, and storage unit replacement.

3. Synthesis

Based on the literature reviewed on the technologies of the garbage collector and Dispensers, the following was observed:

Klepacki (1996) designed waste-handling equipment that can condense trash into a container in a chosen manner. Another invention is a truck body and equipment for automated

recyclable material collecting, as patented by Carson in 1991. It is used to selectively deposit a container containing separated recyclable materials at the curbside and engage, pick up, and dump the container. The body is separated into several containers. A longitudinal track fastened to one side of the truck supports a movably mounted carriage propelled to travel along it. The other device is a modular waste collection system designed by Torres-Muniz et al. (2016) that compresses and sorts recyclable aluminium cans and plastic bottles into many compartments.

The identified state-of-the-art plastic bottle collecting machines have limitations, such as the collection process is selective, motorised power-driven, bulky, and having several compartments. All technologies reviewed are selective in materials and motor power-driven; thus, using them would be expensive in terms of power consumption and require specialised skills in operation. Given the limitations of the preceding prior arts, the study was conceived.

4. Objectives of the Study

Generally, this study aimed to design and fabricate a plastic bottle bin with a dispenser.

Specifically, this study aimed to

1. design an
2. d fabricate a plastic bottle bin with a dispenser; and
3. evaluate the operating performance of the device in terms of dispensing time and efficiency.

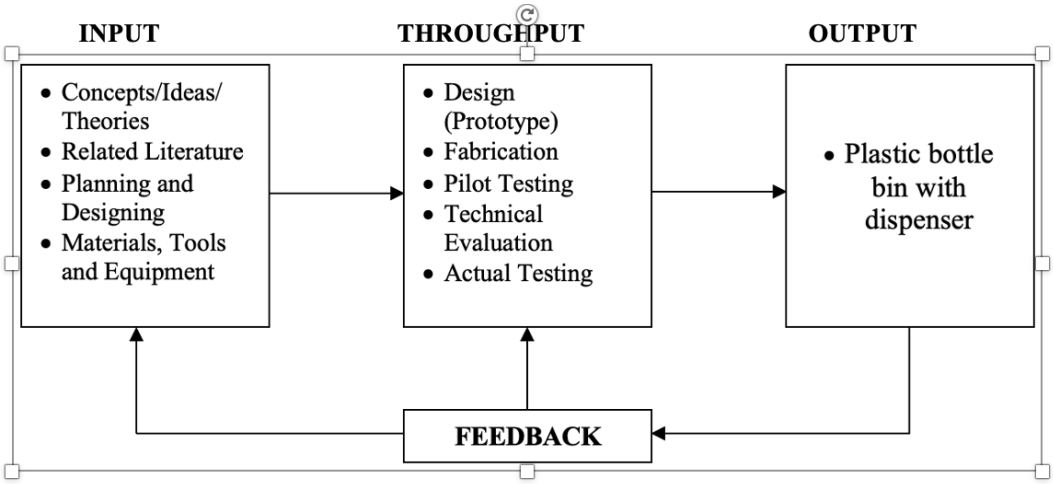

Figure 1. Paradigm of the Study.

Figure 1 shows the conceptual framework of the study. It shows that the independent variables were the respondent's profile and different pipes and bars in different sizes and shapes as welding materials. Nevertheless, the dependent variables are determined and identified by the performance of the PDWJ regarding the setting, clamping, and releasing of the pipes and bars in different sizes and shapes as rated by the respondents.

5. Methodology

5.1 Design Criteria

5.1.1 Structural Framework

The structural structure comprises angle and matt bars that have been welded firmly and securely by industry standards for steel. Additionally, welding standards were developed using the American Welding Society (AWS), which has produced over 350 standards for welding methods and procedures. Among them is the D1.1 Structural Welding Code ¬– Steel, among the most often cited codes worldwide. The rules set by AWS give engineers the direction they need to create designs and fabrications while keeping safety and quality in mind. These laws were created by expert committees and authorised by the American National Standards Institute (ANSI) (AWS, 2024).

5.1.2 Dispenser and slot

The material is made of robust, durable metal that is universally used for steelworks. It is a matt bar with a 1" sieve and is inclined at a particular angle to let the bottles roll freely to the garbage bag for collection. The opening is measured 20 cmx20 cm, enough to dispense the bottles. According to

Dispense-rite (2024), the allowable opening of the Dispenser should be 25% bigger than that of the dispensed bottle.

5.1.3 Depository slot

The material is made of strong and durable metal for collecting plastic bottles. The size is 80cm by 131cm. Furthermore, the shape is frustum, allowing them to be inserted ergonomically inside the chamber.

5.2 Design Plan and Preparation

The plastic bottle collector dispenser was constructed at the Mechanical Technology Department, Iloilo Science and Technology University (ISAT U), La Paz, Iloilo City, Philippines. The design was innovative based on the study of Wong (2005). The nearest prior arts presented were realised to have some disadvantages, which was the basis of the researcher's conducting a further study specifically on the collecting and dispensing of plastic bottles in terms of dispensing time and efficiency.

The device was made using locally made materials available near the researcher. In designing the plastic bottle collector dispenser, the researcher selected materials that could withstand repetitive activities and resist any weather conditions of the device during the collection until dispensing. The main activities involved in using the device were collecting and dispensing plastic bottles and cans of any beverages. The easy access to the depository is located at the upper top portion of the container. The main feature of dispensing is the force of gravity to roll down the bottles into the garbage bag for recycling. That may done quickly in a matter of time, and the plastic bottles can be deposited at any side of the container. Figures 7, 8 and 9 show the proposed design of a Plastic Bottle Collector Dispenser in its three-view drawing and its pictorial drawing with labelled parts, while Figure 10 shows its Isometric view.

5.3 Pilot Testing and Revision

The device was constructed based on the blueprints designed by the researchers. The working drawings were made using AutoCAD and Adobe Illustrator for the top, front, and end views, while in the pictorial views, 3-D Max and Photoshop were used to see the actual materials of the device. A mock-up was made to see the whole picture and the components of the device. The mock-up was used as a reference in fabricating the device. Initial testing was conducted to refine the device.

5.4 Fabrication Procedure

The fabrication of the device was based on the mock-up and final working drawings approved by the researchers. The procedures in the construction of the device are enumerated according to the specifications required in fabricating the plastic bottle collector dispenser device:

1. *Selecting the materials*. In this process, the researchers carefully planned and selected the materials used in the device. The materials used were based on industry standards, such as steel sizes and welding processes that were enough to withstand any weather conditions and repetitive activities.
2. *Purchasing the materials*. The materials were purchased at the researchers' locality. They were inspected for defects and irregularities because of the primary materials to be used for the device.
3. *Cutting, shaping, and finishing the materials according to parts*. In this process, the working drawings were the basis for cutting, shaping, welding, and finishing the device parts. With the aid of the working drawings, the fabrication of a plastic bottle collector dispenser lessens the difficulty for the researchers and the assistant in constructing the device. Durable shaping tools, welding machines, and necessary equipment are prepared to cut and shape the objects to ensure quality in cutting and shaping the parts.
4. *Assembling the parts and other components*. When all the parts were cut, shaped, and finished, they were ready to be assembled. The assembly started from the main frame, followed by the supporting frames and matt bars. All of them are welded for solid bonding. The main legs are supported by a diagonal strut and a base plate for stability when installed on the premises. The matt floor of the collector was installed with extra precaution because it is the device's main feature. The inclination is based on the requirements of free-falling using the force of gravity, leading the items inside to go down into the garbage bag freely.

5. *Designing the dispensing hole.* In this process, the dispensing hole is attached carefully to accommodate any size plastic bottle and not clog the passage. A garbage bag is attached to the dispenser's hole to collect the bottles while dispensing. The last part to be installed is the mechanism for the garbage bag to hold it while dispensing. A locking device locks the lever if not in use for safety.

6. *Testing the device*. In this process, the device was tested according to its efficiency, referring to the dispensing speed of the plastic bottles going through the garbage bag.

7. *Revising the device*. In this process, the plastic bottle collector dispenser was revised based on the suggestions of experts such as engineers, machinists, welders and metal fabricators to improve the assembly of components of the parts to give more accuracy on the outputs in a particular time.

5.5 Technical Evaluation

After the pilot test and revision, the PBCBD was presented to the panel of experts for technical evaluation, suggestions, and recommendations. The evaluation was done in the same venue: the Mechanical Technology Building, Iloilo Science and Technology University, Burgos St., La Paz, Iloilo City, Philippines. Experts were invited to evaluate the device. A typical instrument was utilised to evaluate the device. This questionnaire was designed by the College of Industrial Technology (CIT) for technology research. The evaluation was based on the dispensing time and efficiency of the PBCBD.

5.6 Instrumentation

Actual observation was done using a four-point Likert scale modified questionnaire to test the performance of the PBCBD. It was prepared, set, and tested according to the efficiency and the dispensing time. One person did five trials to get the average and compare the result to the dispensing time from the existing garbage collector. The process involved inserting a generous quantity of plastic bottles into the bin, then releasing through a releasing lever and recording the time dispensing about the number of plastic bottles dispensed. Repetitive operations were done to ensure the Dispenser's performance. The flaws found were noted in the revisions of the PBCBD. Statistical Package for Social Science (SPSS) Version 22 and M.S. Excel were used to process and computerise the data. The statistical tools used were mean and percentage of error. The mean was used to determine the average dispensing time and efficiency. At the 0.05 level of significance, each hypothesis was tested.

5.7 Parameters Analysis

5.7.1 Speed of Dispensing

The dispensing speed is based on the container inclined at a certain angle. The container adopts the pull of gravity to make the plastic bottles roll freely from the dispensing to the garbage bag. A natural way to utilise the nature of gravitational force is to make it easier to put plastics in the waste bag. The human collector will wait until the bag is complete enough to pack and repeat the process until the container is empty.

5.7.2 Efficiency

The efficiency was determined in terms of repetitive operation to finish the dispensing process without interruption. Although "effectiveness" and "efficiency" are sometimes used interchangeably, it is essential to distinguish between the two when examining energy systems. The amount of fuel or primary energy flow a system extracts is measured by its energy efficiency. When an energy system functions well, it directs this energy toward the proper objective. For instance, an automobile can transfer people across large distances and to precise locations, making it a highly effective mode of transportation. Nevertheless, due to its fuel consumption, an automobile might not be the most effective means of moving people (Diffen, n.d.).

6. Conclusions and Recommendations

This study aimed to design and fabricate a plastic bottle bin with a dispenser. Specifically, the design and fabrication of a plastic bottle bin with a dispenser and the operating performance of the device in terms of dispensing time and efficiency should be evaluated. Based on the findings and conclusions, the researcher recommends the following:

1. The device is satisfactory based on the dispensing time, which released the plastic bottles in a maximum of 1 minute per bag.

2. The device is efficient when it comes to collection due to the high degree of freedom of the hole to insert plastic bottles.
3. The overall impression of the panel is that the device is working well and needs to be used in a university-wide waste management program.

7. Acknowledgement

The following people deserve the researchers' heartfelt gratitude for their assistance in finishing this study:

- We appreciate the financial support provided by Dr. Gabriel M. Salistre, Jr., the university president, and the administrative team for making this initiative possible;
- Richard C. De Leon, research director; Dr Carmelo V. Ambut, vice president for research and extension; and Engr. Naci John C. Trance, director of intellectual property management, for recognising the value of this study in research endeavours and
- The evaluators and respondents of the study.

We immensely appreciate all the help, inspiration, and guidance provided to ensure the success of this study. Most importantly, thank the Almighty God for his guidance and assistance during this academic endeavour. We keep doing that as well. We appreciate you.

References

[1] About the Pacific Institute (2012). Pacific Institute. Retrieved from http://www2.pacinst.org/about_us/index.html.
[2] American Welding Society (2024). Codes & Standards. Retrieved from https://www.aws.org/Standards-and-Publications/Codes-and-Standards/#numberOfResults=5
[3] Carson W.S. (1991). Truck Body and Apparatus for Automated Collection of Recyclable Materials. Patent no. 5018929. Retrieved from https://worldwide.espacenet.com/
[4] Cosier, S. (2022). Burning plastic can affect air quality and public health. Retrieved fromhttps://factor.niehs.nih.gov/2022/8/science-highlights/burning-plastic
[5] Dispense-rite.com (2024). Products. Retrieved from https://www.dispense-rite.com/Dispense-Rite/Products.htm
[6] Diffen (n.d.) Effectiveness vs Efficiency [Online], Available: http://www.diffen.com/difference/Effectiveness_vs_Efficiency
[7] Ibwa (2022). Increased consumer demand for bottled water as a healthy alternative to other packaged drinks. Retrieved from https://bottledwater.org/nr/increased-consumer-demand-for-bottled-water-as-a-healthy-alternative-to-other-packaged-drinks/
[8] Iqsdirectory. Com (2024). Plastic bottles. Retrieved from https://www.iqsdirectory.com/articles/blow-molding/plastic-bottles.html
[9] Halden, R. U. (2010). "Plastics and Health Risks". Annual Review of Public Health. 31: 179–94. https://doi.org/10.1146/annurev.publhealth.012809.103714
[10] Kehinde, O., Ramonu, O.J., Babaremu, K.O., & Justin, L.D. (2020). Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria. https://doi.org/10.1016/j.heliyon.2020.e05131
[11] Klepacki et al (1996). Trash Handling Device. Patent No. 5588358. Retrieved from https://worldwide.espacenet.com/
[12] Rustagi, N., Pradhan, S.K., & Singh, R. (2011). Public health impact of plastics: An overview. Indian J Occup Environ Med, 15(3): 100–103. doi: 10.4103/0019-5278.93198
[13] Torres, Muniz et al. (2016). Modular Garbage Collection Apparatus. Patent No. 9272842B1. Retrieved from https://worldwide.espacenet.com/
[14] Wilson, D.C. (2023). Learning from the past to plan for the future: A historical review of waste and resource management evolution 1970–2020 and reflections on priorities 2020–2030 – The perspective of an involved witness. Waste Management & Research, 41(12):1754-1813.